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The investigation of complex formation of tin(IV) with d-tartaric acid by Mössbauer spectroscopy and polarimetry

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Tartarate complexes of tin are widely used in the technological process of printing plates production. We have not got much information about the formation of tin tartarate complexes. For the study of complex formation in solutions we used Mössbauer spectroscopy and polarimetry. Mössbauer spectroscopy gives information about the state of the central atom, the polarimetry gives information about the state of tartaric acid in the complex.

The concentration of metal and ligand varies in the interval 0.001–0.1 mol/l. The specific rotation was calculated by the formula

$$[\alpha]_{\lambda}^{t} = \frac{6.663\alpha}{lB_{m}} \frac{\text{grad dm}^3}{\text{mol}},$$

where α is the observed angle of rotation, l the length of the optical way (dm), and B_m the concentration of optically active substances (mol/l). Mössbauer spectra were taken at a temperature 80 K. The isomer shift is given in relation to the source ($Ba^{119m}SnO_3$).

It is known, that tin(IV) has a strong ability to hydrolyze. That is why all solutions were let stand for a week to establish the equilibrium. The parameters of complex formation were determined by pH-metry at constant volume with the use of computer modeling.

In the system $Sn:H_4Tart$ (1:1) the precipitation was observed in the pH interval from 2 to 11. Parameters of Mössbauer spectra of precipitates ($\delta = 0.055$–0.07 mm/s, $\Delta E = 0.4$–0.55 mm/s) were similar to the parameters of hydroxocomplexes of tin(IV). Consequently, we can suggest that in precipitates the tin is in an octahedral environment and it forms the chains with oxygen bonds between the metal ions.

In the system $sn:H_4Tart$ (1:2, 1:5) Mössbauer spectra are the superposition of two doublets (table 1). The first doublet with parameters ($\delta = 0.05$–0.1 mm/s and $\Delta E = 0.35$–0.66 mm/s) was refered to hydroxocomplexes $Sn(OH)_{6-n}Cl_n^{6-}$. With pH increase the relative effect (ϵ, %) increases too, from 2.9 to 4.14 and from 1.95 to 3.02 for systems 1:2 and 1:5 respectively, that is connected with hydroxoforms.

The second doublet in both systems may be refered to tartrate tin complexes. Tartaric acid coordinates through oxygen of carboxyl and hydroxyl groups and consequently the isomeric shift slightly increases (to 0.17–0.20 mm/s). Quadrupole splitting of the second doublet is two times greater than that of the first one.

Table 1
The parameters of Mössbauer spectra and polarimetry of tin(IV) tartarate

pH	$[\alpha]_{406}^{21}$	I doublet			II doublet		
		ϵ [%]	δ [mm/s]	ΔE [mm/s]	ϵ [%]	δ [mm/s]	ΔE [mm/s]
tin(IV) tartaric acid (1:2)							
1.85	50.8	2.90	0.075	0.35	2.80	0.075	0.90
2.45	70.8	3.13	0.050	0.40	3.07	0.106	1.03
3.63	96.6	3.64	0.050	0.55	2.77	0.175	1.00
4.08	80.8	3.76	0.050	0.50	2.27	0.100	1.00
5.40	83.3	4.14	0.050	0.50	2.35	0.125	0.90
tin(IV) tartaric acid (1:5)							
3.30	100.2	1.95	0.075	0.54	2.40	0.100	0.90
3.75	108.4	1.98	0.040	0.30	2.79	0.120	0.97
4.35	115.6	3.09	0.065	0.62	1.34	0.198	1.18
4.86	123.8	2.73	0.100	0.66	1.44	0.135	0.82
5.48	122.1	3.02	0.088	0.62	0.80	0.175	0.79